CLAIMS

1. Medical imaging and navigation system comprising:

a processor, connected to a display unit and to a database;

a medical positioning system (MPS), connected to said processor, including a transducer MPS sensor and a surgical tool MPS sensor, said surgical tool MPS sensor being firmly attached to a surgical tool;

a two-dimensional imaging system, connected to said processor, including an imaging transducer, said transducer MPS sensor being firmly attached to said imaging transducer;

an inspected organ monitor interface, connected to said processor and to an organ monitor, said organ monitor monitoring an organ timing signal associated with an inspected organ; and

a superimposing processor, connected to said processor.

2. The system according to claim 1, wherein said processor receives:

a plurality of two-dimensional images from said two-dimensional imaging system, acquired by said imaging transducer;

the location and orientation of said imaging transducer from said medical positioning system, as detected by said transducer MPS sensor, for each said two-dimensional images;

said organ timing signal from said inspected organ monitor interface, as detected by said organ monitor, for each said two-dimensional images; and

the location and orientation of said surgical tool, from said medical positioning system, as detected by said surgical tool MPS sensor.

3. The system according to claim 2, wherein said location and orientation of said surgical tool and said location and orientation of said imaging transducer, reside in a single coordinate system.

4. The system according to claim 3, wherein for each said two-dimensional images, said processor stores said two-dimensional image in said database together with said location and orientation information of said imaging transducer, respective of said two-dimensional image and said organ timing signal, respective of said two-dimensional image,

wherein said processor selects at least one of said stored two-dimensional images, having a stored organ timing signal substantially equal to a real time detected organ timing signal,

wherein said superimposing processor superimposes a representation of said surgical tool on a visual representation of said selected two-dimensional images, and

wherein said display presents the result of said superimposing.

5. The system according to claim 4, wherein said visual representation is a three-dimensional reconstructed image produced from said selected two-dimensional images, according to the location and orientation information of said imaging transducer associated with each said selected two-dimensional images.

6. The system according to claim 5, wherein a renderer renders said visual representation according to reference coordinates.

7. The system according to claim 6, wherein said reference coordinates are selected from the list consisting of:

surgical tool coordinates;

inspected organ coordinates; and

coordinates of the body of the patient.

8. The system according to claim 4, wherein said visual representation is two-dimensional.

9. The system according to claim 8, wherein said representation of said surgical tool comprises a projection of a three-dimensional representation of said representation of said surgical tool, on said two-dimensional visual representation.

10. The system according to claim 4, wherein said representation of said surgical tool indicates an estimated location of said surgical tool.

11. The system according to claim 4, wherein said representation of said surgical tool indicates the orientation of said surgical tool.

12. The system according to claim 4, wherein portions of said surgical tool which are located above, below and within a viewed plane, are presented in different colors.

13. The system according to claim 4, wherein said representation of said surgical tool is in the form of a cursor.

14. The system according to claim 4, wherein said representation of said surgical tool is a pseudo realistic visualization of said surgical tool.

15. The system according to claim 4, wherein said visual representation is a three-dimensional reconstruction produced from said selected two-dimensional images, according to the location and orientation information of said imaging transducer associated with said selected

two-dimensional images, discarding portions in said selected two-dimensional images which represent said surgical tool.

16. The system according to claim 1, wherein said database is volumetric.

17. The system according to claim 1, wherein said display includes goggles.

18. The system according to claim 17, wherein said goggles are semi-transparent.

19. The system according to claim 4, wherein said medical positioning system further includes a goggles MPS sensor,

wherein said display includes semi-transparent goggles, being attached to said goggles MPS sensor, and

wherein said processor selects a viewing plane for said visual representation, according to the location and orientation information received from said goggles MPS sensor.

20. The system according to claim 19, wherein said location and orientation of said goggles MPS sensor is provided within said coordinate system.

21. The system according to claim 1, wherein said two-dimensional imaging system is selected from the list consisting of:

ultra-sound;

inner-vascular ultra-sound;

X-ray;

nuclear magnetic resonance;

computerized tomography;

positron-emission tomography; and
single-photon-emission tomography.

22. The system according to claim 1, wherein said surgical tool is selected from the list consisting of:

clamp;
laser cutter;
brush;
catheter;
stent;
balloon;
pace maker electrode;
solution dispensing unit;
neuron electrode;
substance collection unit;
surgical delivery tool;
gene delivery tool;
drug delivery tool; and
device delivery tool.

23. The system according to claim 1, wherein said medical positioning system further includes a body MPS sensor, for attaching to the body of the patient.

24. Medical imaging and navigation system comprising:

a processor, connected to a display unit and to a database;

a medical positioning system (MPS), connected to said processor, including a surgical tool MPS sensor being firmly attached to a surgical tool;

an inspected organ monitor interface, connected to said processor and to an organ monitor, said organ monitor monitoring an organ timing signal associated with an inspected organ; and

a superimposing processor, connected to said processor.

25. The system according to claim 24, wherein said processor receives:

said organ timing signal from said inspected organ monitor interface, as detected by said organ monitor; and

the location and orientation of said surgical tool, from said medical positioning system, as detected by said surgical tool MPS sensor.

26. The system according to claim 25, wherein said processor selects images from said database, each said selected images having a stored organ timing signal substantially equal to a real-time detected organ timing signal,

wherein said superimposing processor superimposes a representation of said surgical tool on said selected images, and

wherein said display presents the result of said superimposing.

27. The system according to claim 26, wherein said selected images are three-dimensional.

28. The system according to claim 26, wherein said selected images are two-dimensional.

29. The system according to claim 28, wherein said representation of said surgical tool comprises a projection of a three-dimensional representation of said representation of said surgical tool, on said two-dimensional images.

30. The system according to claim 24, wherein said database is volumetric.

31. The system according to claim 24, wherein said database is further coupled to an image acquisition system.

32. The system according to claim 24, wherein said display includes goggles.

33. The system according to claim 32, wherein said goggles are semi-transparent.

34. The system according to claim 26, wherein said medical positioning system further includes a goggles MPS sensor,

wherein said display includes semi-transparent goggles, being attached to said goggles MPS sensor, and

wherein said processor selects a viewing plane for said visual representation, according to the location and orientation information received from said goggles MPS sensor.

35. The system according to claim 34, wherein said location and orientation information of said goggles MPS sensor is provided within the coordinate system of said surgical tool MPS sensor.

36. The system according to claim 34, wherein said location and orientation information of said goggles MPS sensor is provided within the coordinate system of said selected images.

37. The system according to claim 24, wherein said two-dimensional imaging system is selected from the list consisting of:

ultra-sound;

inner-vascular ultra-sound;
X-ray;
nuclear magnetic resonance;
computerized tomography;
positron-emission tomography; and
single-photon-emission tomography.

38. The system according to claim 24, wherein said surgical tool is selected from the list consisting of:

clamp;
laser cutter;
brush;
catheter;
stent;
balloon;
pace maker electrode;
solution dispensing unit;
neuron electrode;
substance collection unit;
surgical delivery tool;
gene delivery tool;
drug delivery tool; and
device delivery tool.

39. The system according to claim 24, wherein said medical positioning system further includes a body MPS sensor, for attaching to the body of the patient.

40. Method for displaying an image sequence of a moving inspected organ, the method comprising the steps of:

detecting an organ timing signal of said inspected organ, said organ timing signal defining an organ timing signal cycle;

detecting a plurality of two-dimensional images of said inspected organ, using an image detector;

detecting the location and orientation of said image detector;

associating each of said two-dimensional images with said image detector location and orientation and with said detected organ timing signal;

reconstructing a plurality of three-dimensional images from said two-dimensional images, each said three-dimensional images being reconstructed from two-dimensional images selected from said two-dimensional images, said selected two-dimensional images corresponding to a selected position within said organ timing signal cycle;

selecting one of said three-dimensional images according to a real-time reading of said organ timing signal; and

displaying said selected three-dimensional image.

41. The method according to claim 40, further comprising the following steps prior to said step of reconstructing:

detecting the location and orientation of a surgical tool; and

modifying at least one of said two-dimensional images, by discarding a portion of at least one of said two-dimensional images, said portion representing at least a portion of said surgical tool.

42. The method according to claim 41, wherein said detected location and orientation of said surgical tool and said detected location and orientation of said image detector, both reside in a single coordinate system.

43. The method according to claim 41, further comprising the step of superimposing a representation of said surgical tool onto said selected three-dimensional image, prior to said step of displaying.

44. The method according to claim 40, further comprising the following steps, prior to said step of displaying:

detecting the location and orientation of a surgical tool; and

superimposing a representation of said surgical tool onto said selected three-dimensional image, according to said detected location and orientation of said surgical tool.

45. The method according to claim 40, further comprising the following steps prior to said step of displaying:

detecting the location and orientation of a surgical tool; and

superimposing a representation of said detected location and orientation of said surgical tool, onto said selected three-dimensional image.

46. The method according to claim 40, further comprising, the following steps, after said step of selecting:

detecting the location and orientation of a point of view of a user; and

rendering said selected three-dimensional image according to said detected location and orientation of said point of view.

47. The method according to claim 46, further comprising the following steps prior to said step of rendering:

detecting the location and orientation a surgical tool; and

superimposing a representation of said surgical tool onto said selected three-dimensional image.

48. The method according to claim 46, further comprising the following steps, prior to said step of rendering:

detecting the location and orientation of a surgical tool; and

superimposing a representation of said detected location and orientation of said surgical tool onto said selected three-dimensional image.

49. The method according to claim 46, wherein said step of detecting said location and orientation of said point of view of said user, is performed using a location and orientation sensor attached to user worn goggles.

50. The method according to claim 46, wherein said step of detecting said location and orientation of said point of view of said user, is performed using a location and orientation sensor attached to user worn semi-transparent goggles.

51. The method according to claim 49, wherein the information respective of said location and orientation sensor is provided within the coordinate system of a surgical tool.

52. The method according to claim 49, wherein the information respective of said location and orientation sensor is provided within the coordinate system of said inspected organ.

53. The method according to claim 49, wherein the information respective of said location and orientation sensor is provided within the coordinate system of the body of the patient.

54. The method according to claim 41, wherein said surgical tool is selected from the list consisting of:

clamp;
laser cutter;
brush;
catheter;
stent;
balloon;
pace maker electrode;
solution dispensing unit;
neuron electrode;
substance collection unit;
surgical delivery tool;
gene delivery tool;
drug delivery tool; and
device delivery tool.

55. The method according to claim 43, wherein said representation of said surgical tool indicates an estimated location of said surgical tool.

56. The method according to claim 43, wherein said representation of said surgical tool indicates the orientation of said surgical tool.

57. The method according to claim 43, wherein portions of said surgical tool which are located above, below and within a viewed plane, are presented in different colors.

58. The method according to claim 43, wherein said representation of said surgical tool is in the form of a cursor.

59. The method according to claim 43, wherein said representation of said surgical tool is a pseudo realistic visualization of said surgical tool.

60. The method according to claim 40, wherein said step of reconstruction is performed according to the location and orientation information associated with each said selected two-dimensional images.

61. The method according to claim 40, further comprising the step of discarding portions in said selected two-dimensional images which represent a surgical tool, prior to said step of reconstructing.

62. The method according to claim 43, wherein said representation of said surgical tool comprises a projection of a three-dimensional representation of said representation of said surgical tool, on each of said two-dimensional images.

63. Method for displaying an image sequence of a moving inspected organ, the method comprising the steps of:

detecting an organ timing signal of said inspected organ, said organ timing signal defining an organ timing signal cycle;

selecting one of a previously stored three-dimensional images according to a real-time reading of said organ timing signal;

detecting the location and orientation of a surgical tool;

superimposing a representation of said surgical tool onto said selected three-dimensional image; and

displaying said superimposed three-dimensional image.

64. The method according to claim 63, further comprising the following steps prior to said step of selecting:

detecting a plurality of two-dimensional images of said inspected organ, using an image detector;

detecting the location and orientation of said image detector;

associating each of said two-dimensional images with said location and orientation of said two-dimensional image and with a reading of said organ timing signal detected at the time of acquiring said two-dimensional image; and

reconstructing a plurality of three-dimensional images from said two-dimensional images, each said three-dimensional images being reconstructed from two-dimensional images selected from said two-dimensional images, said selected two-dimensional images corresponding to a selected position within said organ timing signal cycle.

65. The method according to claim 64, wherein said detected location and orientation of said surgical tool and said detected location and orientation of said image detector, both reside in a single coordinate system.

66. The method according to claim 64, further comprising a step of modifying at least one of said two-dimensional images, by discarding a portion thereof which represents at least a portion of said surgical tool, wherein said step of modifying is performed following said step of associating, and following said step of detecting said surgical tool location and orientation.

67. The method according to claim 63, further comprising the following steps, before said step of displaying:

detecting the location and orientation of a point of view of a user; and

rendering said selected three-dimensional image according to said detected location and orientation of said point of view.

68. The method according to claim 67, wherein said step of detecting said location and orientation of said point of view of said user, is performed using a location and orientation sensor attached to user worn goggles.

69. The method according to claim 67, wherein said step of detecting said location and orientation of said point of view of said user, is performed using a location and orientation sensor attached to user worn semi-transparent goggles.

70. The method according to claim 68, wherein the information respective of said location and orientation sensor is provided within the coordinate system of said surgical tool.

71. The method according to claim 68, wherein the information respective of said location and orientation sensor is provided within the coordinate system of said inspected organ.

72. The method according to claim 68, wherein the information respective of said location and orientation sensor is provided within the coordinate system of the body of the patient.

73. The method according to claim 63, wherein said surgical tool is selected from the list consisting of:

clamp;
laser cutter;
brush;
catheter;
stent;
balloon;
pace maker electrode;

solution dispensing unit;
neuron electrode;
substance collection unit;
surgical delivery tool;
gene delivery tool;
drug delivery tool; and
device delivery tool.

74. The method according to claim 63, wherein said representation of said surgical tool indicates an estimated location of said surgical tool.

75. The method according to claim 63, wherein said representation of said surgical tool indicates the orientation of said surgical tool.

76. The method according to claim 63, wherein portions of said surgical tool which are located above, below and within a viewed plane, are presented in different colors.

77. The method according to claim 63, wherein said representation of said surgical tool is in the form of a cursor.

78. The method according to claim 63, wherein said representation of said surgical tool is a pseudo realistic visualization of said surgical tool.

79. The method according to claim 63, wherein said step of reconstruction is performed according to the location and orientation information associated with each said selected two-dimensional images.

80. The method according to claim 63, further comprising the step of discarding portions in said selected two-dimensional images which represent said surgical tool, prior to said step of reconstructing.

81. The method according to claim 64, wherein said representation of said surgical tool comprises a projection of a three-dimensional representation of said representation of said surgical tool, on each of said two-dimensional images.

82. Method for displaying an image sequence of a moving inspected organ, the method comprising the steps of:

detecting an organ timing signal of said inspected organ, said organ timing signal defining an organ timing signal cycle;

detecting the location and orientation of a point of view of a user;

selecting one of a previously stored three-dimensional images according to a real-time reading of said organ timing signal;

rendering said selected three-dimensional image according to said detected location and orientation of said point of view; and

displaying said selected three-dimensional image.

83. The method according to claim 82, further comprising the following steps prior to said step of selecting:

detecting a plurality of two-dimensional images of said inspected organ, using an image detector;

detecting the location and orientation of said image detector;

associating each of said two-dimensional images with said location and orientation of said two-dimensional image and with a reading of said organ timing signal detected at the time of acquiring said two-dimensional image; and

reconstructing a plurality of three-dimensional images from said two-dimensional images, each said three-dimensional images being

reconstructed from two-dimensional images selected from said two-dimensional images, said selected two-dimensional images corresponding to a selected position within said organ timing signal cycle.

84. The method according to claim 83, further comprising the following steps prior to said step of reconstructing:

detecting the location and orientation of a surgical tool; and

modifying at least one of said two-dimensional images, by discarding a portion of at least one of said two-dimensional images, said portion representing at least a portion of said surgical tool.

85. The method according to claim 84, wherein said detected location and orientation of said surgical tool and said detected location and orientation of said image detector, both reside in a single coordinate system.

86. The method according to claim 84, further comprising the step of superimposing a representation of said surgical tool onto said selected three-dimensional image, prior to said step of displaying.

87. The method according to claim 83, further comprising the following steps, after said step of associating:

detecting the location and orientation of a surgical tool;

modifying at least one of said two-dimensional images, by discarding a portion of at least one of said two-dimensional images, which represents said surgical tool; and

superimposing a representation of said surgical tool onto said selected three-dimensional image.

88. The method according to claim 82, wherein said step of detecting said location and orientation of said point of view of said user, is performed using a location and orientation sensor attached to user worn goggles.

89. The method according to claim 82, wherein said step of detecting said location and orientation of said point of view of said user, is performed using a location and orientation sensor attached to user worn semi-transparent goggles.

90. The method according to claim 88, wherein the information respective of said location and orientation sensor is provided within the coordinate system of a surgical tool.

91. The method according to claim 88, wherein the information respective of said location and orientation sensor is provided within the coordinate system of said inspected organ.

92. The method according to claim 88, wherein the information respective of said location and orientation sensor is provided within the coordinate system of the body of the patient.

93. The method according to claim 84, wherein said surgical tool is selected from the list consisting of:

clamp;
laser cutter;
brush;
catheter;
stent;
balloon;
pace maker electrode;

solution dispensing unit;
neuron electrode;
substance collection unit;
surgical delivery tool;
gene delivery tool;
drug delivery tool; and
device delivery tool.

94. The method according to claim 86, wherein said representation of said surgical tool indicates an estimated location of said surgical tool.

95. The method according to claim 86, wherein said representation of said surgical tool indicates the orientation of said surgical tool.

96. The method according to claim 86, wherein portions of said surgical tool which are located above, below and within a viewed plane, are presented in different colors.

97. The method according to claim 86, wherein said representation of said surgical tool is in the form of a cursor.

98. The method according to claim 86, wherein said representation of said surgical tool is a pseudo realistic visualization of said surgical tool.

99. The method according to claim 83, further comprising the step of discarding portions in said selected two-dimensional images which represent a surgical tool, prior to said step of reconstructing.

100. The method according to claim 86, wherein said representation of said surgical tool comprises a projection of a three-dimensional

representation of said representation of said surgical tool, on each of said two-dimensional images.

101. Method for displaying an image sequence of a moving inspected organ, each image in said image sequence being associated with the location and orientation thereof within a predetermined coordinate system, the method comprising the steps of:

detecting an organ timing signal of said inspected organ;

selecting one of a previously stored two-dimensional images according to a real-time reading of said organ timing signal; and

displaying said selected two-dimensional image.

102. The method according to claim 101, further comprising the following steps, before said step of displaying:

detecting the location and orientation of a surgical tool; and

projecting a representation of said surgical tool onto said selected two-dimensional image.

103. The method according to claim 101, further comprising the preliminary steps of:

detecting a plurality of two-dimensional images of said inspected organ, using an image detector; and

detecting the location and orientation of said image detector for each said two-dimensional images.

104. The method according to claim 102, further comprising the preliminary steps of:

detecting a plurality of two-dimensional images of said inspected organ, using an image detector; and

detecting the location and orientation of said image detector.

105. The method according to claim 104, further comprising the preliminary step of storing said two-dimensional images and the respective said detected locations and orientations of said image detector, in a database.

106. The method according to claim 103, further comprising the preliminary steps of:

determining if at least one of said two-dimensional images deviates from a selected plane; and

reporting said deviation.

107. The method according to claim 101, further comprising the step of detecting the location and orientation of a point of view of a user, before said step of displaying, wherein said stored two-dimensional image is selected according to said detected location and orientation of said point of view.

108. The method according to claim 107, further comprising the preliminary steps of:

detecting a plurality of two-dimensional images of said inspected organ, using an image detector;

detecting the location and orientation of said image detector, respective of each of said two-dimensional images; and

storing said two-dimensional images and the respective said detected locations and orientations of said image detector, in a database.

109. The method according to claim 107, wherein said step of detecting said location and orientation of said point of view of said user, is performed using a location and orientation sensor attached to user worn goggles.

110. The method according to claim 104, wherein said detected location and orientation of said surgical tool and said detected location and orientation of said image detector, both reside in a single coordinate system.

111. The method according to claim 109, wherein the information respective of said location and orientation sensor is provided within the coordinate system of a surgical tool.

112. The method according to claim 109, wherein the information respective of said location and orientation sensor is provided within the coordinate system of said inspected organ.

113. The method according to claim 109, wherein the information respective of said location and orientation sensor is provided within the coordinate system of the body of the patient.

114. The method according to claim 102, wherein said surgical tool is selected from the list consisting of:

clamp;
laser cutter;
brush;
catheter;
stent;
balloon;
pace maker electrode;
solution dispensing unit;
neuron electrode;
substance collection unit;
surgical delivery tool;

gene delivery tool;
drug delivery tool; and
device delivery tool.

115. The method according to claim 102, wherein said representation of said surgical tool indicates an estimated location of said surgical tool.

116. The method according to claim 102, wherein said representation of said surgical tool indicates the orientation of said surgical tool.

117. The method according to claim 102, wherein portions of said surgical tool which are located above, below and within said selected two-dimensional image, are presented in different colors.

118. The method according to claim 102, wherein said representation of said surgical tool is in the form of a cursor.

119. The method according to claim 102, wherein said representation of said surgical tool is a pseudo realistic visualization of said surgical tool.